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The Insecticidal Properties of Indigenous Vegetable Fish Poisons

BY

T. V. Subramaniam
Offg. Entomologist, Mysore Agricultural Department

The increasing use of insecticides in the control of crop pests has rendered necessary the obtaining of cheap and effective substitutes for the costly ones that have been in use. The insecticidal value of *Pyrethrum* has been known from a long time and its active principle *Pyrethrin* has been extracted and forms the ingredient of several proprietary insecticides. The value of the plant has been so much recognized that its cultivation, chiefly confined hitherto to Japan, Persia and Turkey, has now been extended to France and England.

Several species of Derris belonging to the Papilionaceæ have been known to be used for poisoning fish in Borneo and Malay States of which *Derris elliptica* known there commonly as Tuba or Coo'bay is one. These plants are found growing wild in the above places. As early as 1848 the root of Derris has been reported to be used as an insecticide. The Agricultural Department, Federated Malay States, has been investigating the insecticidal properties of Derris with water extracts and crude powders of the roots from 1916

onwards against various crop and animal pests and the toxic properties of the plant roots have been definitely established. The insecticidal value of the plant has been so much recognized in America and Europe, that, following the great demand for the material, very large plantations of Derris—3000 acres in Federated Malay States and 2000 acres in Borneo—have been started and the export of the plant roots from Borneo alone increased from 581 tons in 1928 to 691 tons in 1929, the chief market being the United Kingdom.

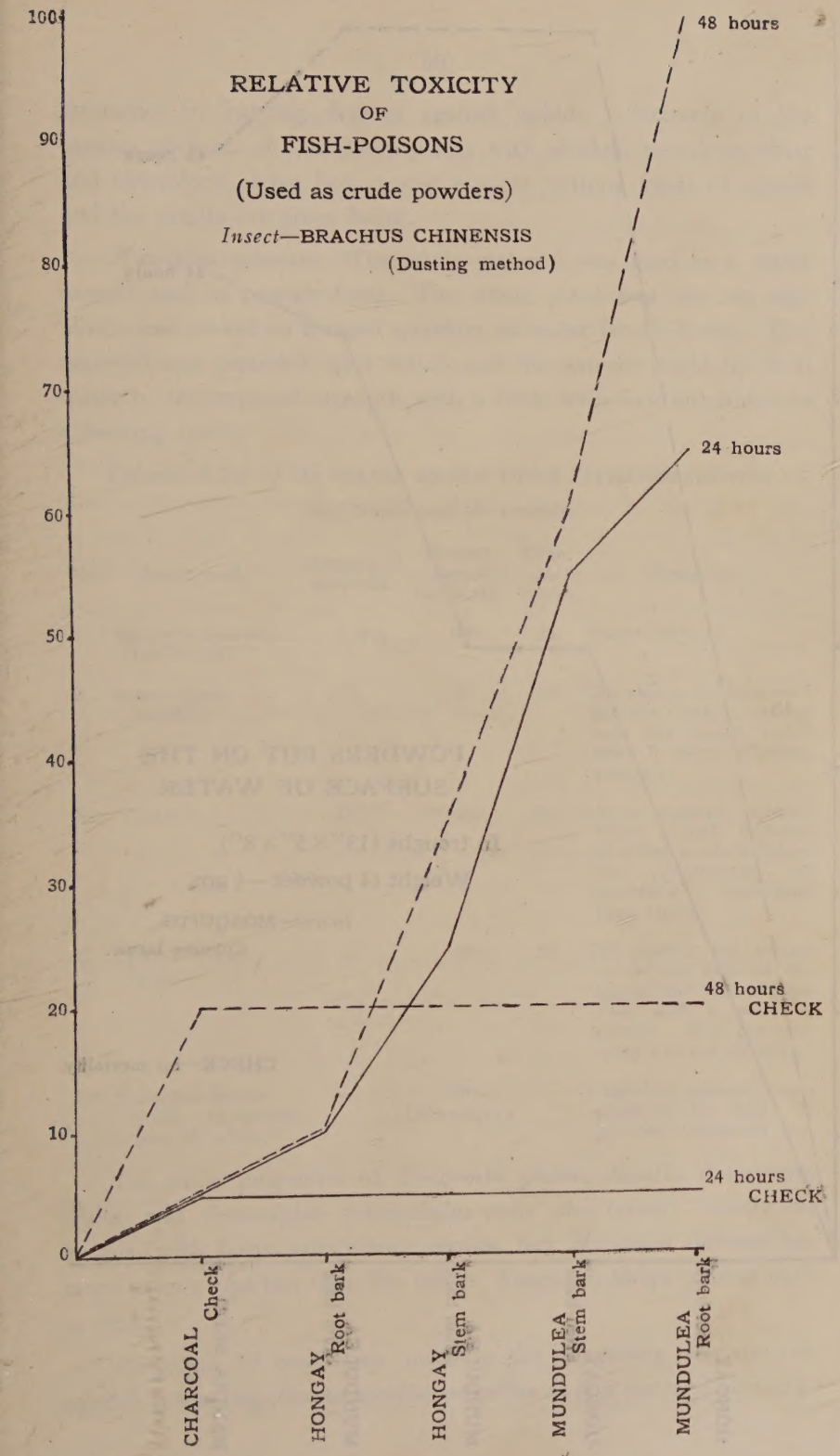
The most potent insecticidal principle of Derris, formerly known as *Derrin*, is now known as "*Rotenone*". Rotenone has very powerful insecticidal properties. One gram of Rotenone in 300 litres of water (a dilution of 1 in 300,000) effectively controlled species of plant lice in America. It has been found to be more toxic to some insects than lead arsenate—one of the common insecticides in general use.

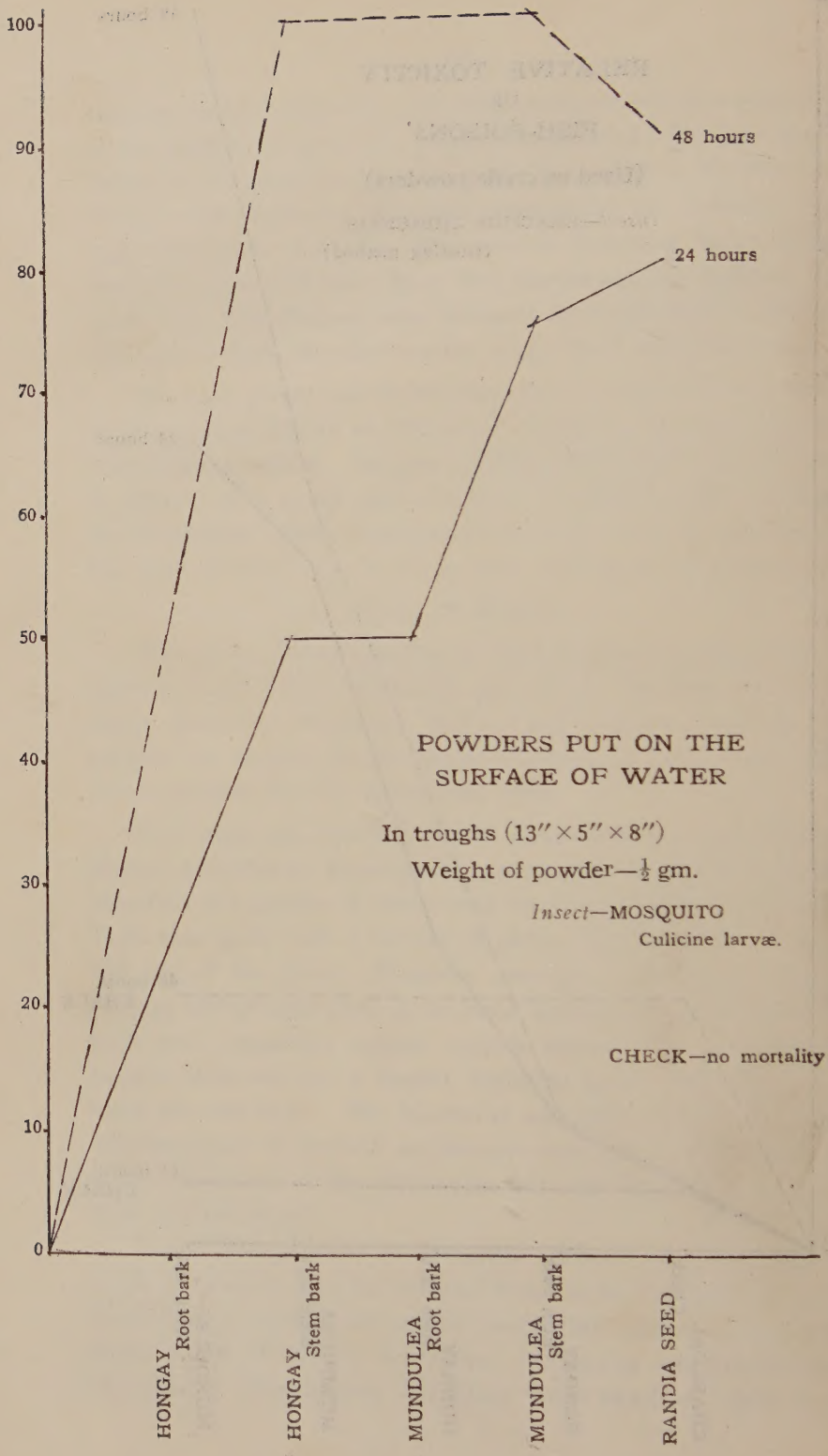
Work in Mysore.

Ten species of Derris plants have been reported to occur in South India of which *Derris scandens* is met with in the State, but not in large quantities. McIndoo, Sievers and Abbott (America), on analysis of various Derris species occurring in Java, found that *Derris scandens* has no insecticidal value.

Five years ago, the late Dr. K. Kunhi Kannan, Entomologist, Mysore Agricultural Department, commenced the work with the collection of a number of plants used for poisoning fish in the State. Tests were made with a number of plants against various insects and one of the plants, *Mundulea suberosa* (Papilionaceæ), found growing wild in large areas in the State, has been found to have very good toxic properties against various insects like mangohopper nymphs (*Idiocerus* sp., a Jassid), Epilachna grubs, mosquito larvæ, cattle lice and fleas. The laboratory and field tests were so very encouraging as to warrant an intensive work on the chemical side in the separation of the active principle and finding out its toxic value against insects.

The active principle of *Mundulea suberosa* has been isolated by M. Greshoff in Java in 1899 and found to be Derrin (Rotenone). Other plants tested by us for their insecticidal value were *Pongamia glabra*, fruits of *Randia dumetorum* (Rubiaceæ) and *Lasiosiphon eriocephalus* (Thyacliaceæ) and these were found to have toxic


RELATIVE TOXICITY
OF
FISH-POISONS
(Used as crude powders)
Insect—BRACHUS CHINENSIS
(Dusting method)
100
90
80
70
60
50
40
30
20
10
0
48 hours
24 hours
48 hours
CHECK
24 hours
CHECK
CHARCOAL
Check
HONGAY
Root bark
HONGAY
Stem bark
MUNDULEA
Stem bark
MUNDULEA
Root bark


100
90
80
70
60
50
40
30
20
10
0
48 hours
24 hours
POWDERS PUT ON THE SURFACE OF WATER
In troughs (13″ × 5″ × 8″)
Weight of powder—½ gm.
Insect—MOSQUITO
Culicine larvæ.
CHECK—no mortality
HONGAY Root bark
HONGAY Stem bark
MUNDULEA Root bark
MUNDULEA Stem bark
RANDIA SEED

properties in varying degrees against aphids. Extracts of the various portions of the above plants with alcohol, petroleum-ether and chloroform, have been tested against various kinds of aphids and the results are given below.

Mundulea suberosa.—The crude material was used as a water extract and in powder form. The whole plant was cut up into pieces and soaked in a small quantity of water for 12 hours. This material was pounded with water and the extract made up with water to the required strength with a little soap solution added as a wetting agent.

Tabulated list of the insects against which Mundulea suberosa was tested and the results.

No.	Insect used.	Strength of material.	Percentage of mortality.	Time in hours.	Remarks.
1.	Idiocerus nymphs (on mango)	0.5%	100	24	Water extract.
2.	Grasshoppers (surface)	1%	87	72	The insects are immersed in the water extract and the result noted after 3 days. (Contact poison.)
3.	Do. ..	1%	25	72	(As a stomach poison.) When a little molasses is added to the mixture the percentage of mortality increased three times.
4.	Cattle lice and fleas	—	90	24	The powder was rubbed on to the skin of the animal and then covered over with a piece of gunny. A 5 per cent spray was not effective.
5.	Epilachna beetle grubs. (A serious pest of potato.)	—	100 (Laboratory)	..	Dusted on infested potato plants in the field. 70 per cent mortality.

The toxic properties of *Pongamia glabra*, *Randia dumetorum* fruits, and *Lasiosiphon eriocephalus* were also tested, mostly on aphids, with fairly satisfactory results, but *Mundulea suberosa* has more toxic properties than the others, *Pongamia glabra* coming next in rank.

Pongamia oil resin soap made in the laboratory was sprayed against green bug (*Coccus viridis*) on coffee at a 2 per cent strength.

In 24 hours all the nymphs of the scale were found dead and in 48 hours the adults were dead. This compares very favourably with fish oil resin soap generally used as a contact insecticide.

A quantitative determination of the toxicity of the different plant products was made in the laboratory with the store pest (*Brachus chinensis*). Powders of uniform fineness of the different portions of plants, *Mundulea suberosa* and *Pongamia glabra*, etc., were made and a definite quantity of the powdered material was put in tubes and live insects dropped into the powders and after allowing them to remain there for about 5 seconds, were removed to a clean tube and the condition of the insects noted after 24 hours and 48 hours. For check, charcoal powder of the same consistency was used.

The results obtained were more or less confirmatory of those obtained by spraying, etc., on aphids. The accompanying graph gives the comparative toxicity of the different materials.

A very important consideration in the use of the local plants as insecticides is their cheapness, availability, non-poisonous nature to animals and human beings, and absence of injury even to the tenderest portions of the plants to which they are applied as against the costly arsenical poisons, the general use of which against crop pests is attended with great danger particularly in the hands of our ryots.

Groundnut : Soil, Rainfall, Cultivation, Varieties under Cultivation, Pests and Diseases

BY

Venkata Rao K. Badami, L.Ag., Ph.D. (Cantab.)

Economic Botanist to the Government of Mysore

India, West Africa and the United States of America are the most important groundnut producing countries. The methods of cultivation adopted by the farmers of the United States are the most modern. Machinery is used to the greatest extent. There are very good banking facilities and a ready home market which consumes all the nuts produced in the country. The trade is well organized. There are associations to safeguard the interest of the industry. In West Africa, the conditions are quite different. Areas

suitable for groundnut are distributed over a number of colonies belonging to the French and the British. The methods of cultivation are the most primitive. Most of the cultivation is done by manual labour. The existence of various deadly cattle diseases prevents the utilization of animal power in farming. The colonies are not so well developed as to use machinery freely. In most cases the produce of the land has to be carried as head-loads or donkey-loads for several days before a market is reached. The collected produce is transported to the ports either by river or rail. The railways are still quite undeveloped. In Nigeria and in French Soudan transport facilities are good. The Nigerian Railway brings the produce from Kano and the surrounding area to the coast. The French Soudan Railways connect the Niger valley with Dakar on the Atlantic. The prosperity of these regions is more or less dependent upon the successful harvests of groundnuts. There is no home market for the nuts in West Africa. All the nuts are exported, mostly to France. Being very near to Europe the freight on ship loads is cheaper than for any other country. The situation is admirable for trade but the undeveloped nature of the country, the divisions of the country amongst various governments, and the limitations due to the natural obstacles are very great impediments in the progress of the industry. On the other hand, in India there is a happy combination of the facilities necessary for building up a great industry. The country is under one, settled, progressive government. The people are experienced cultivators, labour is cheap and there is a happy combination of both animal and hand labour on the farms. The climate and soils are very well suited for groundnut production. The home market is very promising. Roads and railways, harbour facilities and banking systems are all favourable. The only draw-back is the distance to the European market. To reduce the cost of shipping, decorticated nuts are exported and the consignments often arrive in Europe in a very mouldy condition. If the nuts could only be sent to Europe unshelled, India can put on the market grades of nuts as good as those from West Africa.

An attempt is made to give here a summary of the conditions under which groundnut is grown in the three countries mentioned above, namely, the United States of America, India and the West

Coast of Africa. In all these places where groundnut is grown the soils are mostly sandy and the climatic conditions are fit for growing grain crops. The general methods of cultivation are the most advanced in the States. In India the crop is grown in the same way as the other crops, *i.e.*, in the old traditional way with the help of bullocks and indigenous plough and cultivating implements. In Africa the system of cultivation is still less developed ; most of the operations are being done mainly by manual labour and implements worked by hand. However, with the establishment of Agricultural Colleges, Research Institutes and the example set by the forward planters, the phase of agricultural development is changing fast and country after country is coming into the line of modern farming methods, gradually using improved implements, planning better rotations, utilizing artificial manures and adapting methods to cut down cost of production and marketing.

The United States of America.

Climate.—A season of 100 to 140 days, without frost, a moderate amount of rainfall ranging from 42 to 54 inches and a relatively high temperature during the growing period are the general requirements of the groundnut crop. It seems to stand both drought and excessive rainfall fairly well. Successful crops have been raised with a low rainfall of 19 inches and fall of 54 to 60 inches has not damaged the crop even on low, flat valley lands with good subsoil drainage. The co-efficient of wilting point in the soil is said to be 2.5 per cent. During the period of growth the average rate of wind varies from six to three miles per hour in Texas. From the time of sowing there is a rise in the temperature with a decrease in range. High temperature with the prevailing winds causes a high rate of transpiration. During the cropping period there is plenty of sunshine and very few cloudy days. Temperature variations during the season are as follows :—

Month.	Max. Temp.	Min. Temp.	Range.
April ..	80	38	42
May ..	99	45	54
June ..	103	51	52
July ..	104	62	42
August (1-15) ..	105	68	37

Soil.—A well-drained, light sandy soil fit for growing beans and potatoes is fit for groundnut. Sour and poor soils are not generally fit for it. It grows on all kinds of soils, except on very heavy clays, for forage purposes.

Physical analysis according to "Schloesing method".—

Soil.	Byrms.	James Island.	Anderson Ville.
Pebbles and gravel			
Silica ..	4.23	3.55	24.76
Calcareous ..	*trace*	0.36	1.89
Coarse org. matter ..	2.22	4.63	1.56
	6.45	8.54	28.21
Coarse sand silica ..	886.80	862.99	806.21
Calcareous ..	0.40	0.50	0.98
Org. matter ..	3.09	2.79	3.63
Fine sand silica ..	82.76	97.68	123.27
Calcareous ..	0.34	0.76	1.42
Fine org. matter ..	11.79	15.67	18.66
Clay ..	3.54	5.84	9.64
Humus ..	4.83	5.23	8.02
	1000.0	1000.0	1000.0
Chemical Analysis.—			
Nitrogen ..	0.42	0.48	1.04
Phosphoric Acid ..	0.41	0.50	0.77
Calcium ..	0.42	0.70	1.40
Potash ..	0.47	0.37	0.91
Yields in these soils per acre ..	896 lbs.	moderate yield	1344 lbs.

In the northern states the crops are uncertain; and they are specially raised for feeding hogs. Along the Atlantic coast in Carolina and Virginia large podded varieties like Virginia bunch and Virginia runner are grown. Around the Gulf Coast region types like the Spanish variety grow most satisfactorily.

Preparation of Soil.—Cow peas, velvet beans, sweet potatoes, Irish potatoes are good crops for rotation. Sometimes groundnut

is grown in between the rows of maize. Corn and cotton stalks interfere with cultivation. It is grown in the same soil once in three or four years. A renovating crop like clover is said to be beneficial in the rotation.

Cultivation is started six weeks before sowing and a thorough preparation is given before sowing.

Fresh manure seems to have a tendency to produce many empty pods. Generally the previous crop is manured. The following commercial manures are often used :

(A) 300 to 500 lbs. per acre of a mixture containing

Phosphoric acid	8	per cent.
Nitrogen	2	,,
Potash	2 to 3	,,

(B) A dressing of 200 lbs. per acre of a mixture having

Phosphoric acid	16	per cent.
Cotton seed meal	100	,,

Fertilizers are used just before planting. If the soil is rich or has had green manuring no artificial manure is necessary. Soils deficient in lime require a dressing of 400 to 800 lbs. of lime per acre. It is applied a week or ten days before or after applying fertilizers. Lime is spread on the surface and harrowed into the soil. Unleached wood ashes containing potash and lime are said to be useful for groundnuts and generally a dressing of 800 to 1200 lbs. of such ash is given. Though the plant is a legume it does not leave behind in the soil much of the nitrogen it gathers. If the roots are left in the soil at harvest time probably a little more nitrogen will be left behind.

Seed.—A high grade seed is necessary for sowing. It must be carefully cleaned and shelled by hand if possible. Injury to seed coat affects germination. Breaking the pods in two serves the same purpose as shelling. Coating the seeds with a mixture of pine tar and kerosene seems necessary to keep off the rodents. About 20 to 30 lbs. of seeds are required for sowing an acre.

Season.—The main sowing season in the commercial areas is between April 10th and May 10th. In no case is sowing done before the soil is warm enough. There is not much difference in the ripening periods of the smaller and bigger types. Round the Gulf Coast sowings may be done as late as July 1st.

Cultivation.—Distance of planting in rows varies with variety and local conditions. Distance between rows varies between 32 to 42 inches. In light sandy loams dropping seeds 3 inches apart in rows 30 inches apart seems to be beneficial. With Spanish varieties it is proper to sow in closer rows. Though close planting takes more seed it guards against damages done by cultivating implements and rodents.

Table of Planting Distance for Groundnuts.

Variety.	Distance in inches. Between rows.	In rows.
Spanish ..	32 to 38	7 to 8
Valencia, Tennesse Red, Georgia Red	32 to 42	8 to 12
Virginia Bunch ..	32 to 38	8 to 12
Virginia Runner ..	36 to 42	12 to 18
North Carolina ..	34 to 38	12 to 15
African ..	36 to 42	12 to 18

Recent experiments conducted by the Experiment Station in South Carolina between 1917 and 1919 and the results published in 1927 go to show that closer planting of rows and in the rows gives higher yields. The results published in the U. S. Department of Agriculture (*Dep. Bul.*, No. 1478 of March ~~1827~~ 1927 and the results obtained by me in my experiments are similar. These will be referred to again in another chapter.

Seeds are covered to a depth of 1½ to 2 inches. Shallower sowing in moist and heavy soils is recommended. Sowing is generally done with a planter but sometimes furrows are opened and the seeds dropped in. The subsequent furrow covers the seed. Slight consolidation of the soil is desirable.

One hand hoeing and frequent harrowing with a toothed harrow are necessary to keep the surface in a fine mulch. It is injurious to pass implements over the crop when the fruiting stalks have begun to get into the ground. Passing a light roller may help to form more pods in spreading types.

Harvesting.—A yield of 900 to 1,500 lbs. is a fair one. One thousand eight hundred to 2,000 lbs. have been sometimes harvested.

The first indication of ripening is the yellowing of leaf. Plants are dug up and examined to see if the seeds have begun to ripe. If

the seeds are ripe they begin to colour and show darkened veins. If left too long in the ground all the leaves shed and many pods begin to germinate.

Various devices have been tried to lift the crop. Potato diggers with elevators have proved useful. After the plants are loosened from the soil they are spread upon the ground or in small bunches and allowed to wilt a little before they are carted for stacking.

Two cross pieces of 14 to 18 inches are nailed at right angles to one another to one end of a pole 7 feet in length and about 3 inches in diameter at the base. 15 to 30 such poles are necessary to stack the harvest of a plot. The plants are arranged over the cross pieces round the pole and left on the field as small stacks. A cart goes over the field, collects all the small stacks and carts them to a central stack where the nuts are separated from the plants by machines. These small stacks are built up with all the nuts inside and with the centre a little higher than the edges. The top is covered by a layer of straw or grass. There is good aeration, proper curing is effected and the method facilitates easy carting.

The period of curing is about 6 weeks. Picking is done by hand or by machines. About 120 lbs. of nuts are put in a standard size bag 32 × 36 inches. A lining of woven wire inside the bags with a half inch mesh keeps off rats. The nuts contain moisture at this stage and the bags are placed in stores on scantlings to allow free circulation of air.

More often the nuts are again passed through the cleaners before bagging for market. Standard grades have been adopted in several southern states, based upon the quantity or percentage of first class kernels that may be shelled from a given sample.

Classes.

Class I. White Spanish.
II. Bunch.
III. Runners.
IV. Mixed.

Note :—

1. Mixed nuts include—
   (*a*) mixture of other varieties ;
   (*b*) samples containing more than 2 per cent shelled nuts.

2. "Sound Kernels" mean bright, mature and marketable nuts.
3. "Damaged Nuts" mean those nuts that are not prime in flavour, mouldy, sour, rancid or wholly or partly decomposed.
4. Percentages by weight are based on the samples of farmer's stock, hand shelled.
5. Deductions are made for foreign matter above 1 per cent and moisture above 7 per cent.
6. Samples. (*a*) Six samples of 5 lbs. each from various parts of each car.
   (*b*) Two samples of 2 lbs. each from a waggon load.

For examination the samples are thoroughly mixed, then quartered and 100 grams shelled by hand as a basis for determining grade.

Though this elaborate grading is not suitable in all countries there is much to be said in its favour. A standard of grading for each country will help the marketing of the produce to the best advantage.

In spite of over four million acres under cultivation the produce is not sufficient to meet the local demand. Ninety-eight thousand cwts. of oil were imported from Europe specially from France, Germany and Holland. In 1912-13 the U.S.A. exported to Canada 47,926 cwts. More area is coming under cultivation but the outturn per acre seems to be falling off. The total area under groundnuts in the States is now nearly 4,000,000 acres or even more, for half of this area is fed off by hogs.

India.

Soil.—The best soil for groundnut is supposed to be a light ash coloured soil, absorptive and fairly retentive of moisture. But such areas are rarely met with. The general types of soils are light sandy ones derived from sandstone or laterite in character. Red sandy soils are very popular with the Madras cultivator for growing groundnuts. On the east coast, south of Madras, fairly good crops are raised on soils formed by drift sand. In the hilly parts of Mysore, and parts of the Bombay Presidency the soils are generally derived

from the disintegration of gneiss. In other parts of the Deccan plateau it is the usual black cotton soil of the trap region.

The amount of rainfall varies between 20 inches to 45 or 50 inches. With the help of 4 or 5 inches of rain during April and May cultivation begins. Sowing takes place in June or July, and throughout the monsoon the crop grows and ripens before the cold weather in December. Rain during the period varies from 15 inches to 25 inches. On the east coast and littoral regions heavy rainfalls occur from October to December: but the soils are well drained and very little damage is done to the crops. Temperature is high throughout, ranging from 80° to 100° or 108° on the plains and from 70° to 90° on the table-lands when elevation varies between 1000 to 3000 feet. Sometimes the evaporation is very great, *e.g.*, when a steady S.-W. monsoon breeze sets in. Nearly $\frac{1}{4}$ inch water evaporates per day from a free surface of a sheet of water. Often the rains fail and the crop suffers in the later stages of its growth. The ground gets very dry and the cost of lifting the crop becomes excessive, as no better and successful method of digging the nut has replaced hand digging and picking. Sometimes a burst of cyclone all over the country moistens the soil so much that ripe nuts begin to sprout in the soil and damage the crop very much.

The soils are generally poor in lime, contain very little of phosphoric acid and are deficient in nitrogen but contain a fair amount of potash.

Analysis of groundnut soils from South Arcot District, Madras by Dr. Leather.

Sample Number ..	381	382	383	384	385	386
Contents ..	Good soil	Fertile	Continuous cropping manured	Less fertile than 382	Manured and cropped heavily	Same as 386
Insoluble silicates and sand.	82.33	95.04	87.61	77.09	96.01	93.71
Nitrogen ..	0.17	0.01	0.009	0.008	0.023	0.19
Phosphoric Acid (P_2O_5) ..	0.06	0.03	0.10	0.14	0.04	0.04
Potash (K_2O) and Soda (Na_2O)	0.98	0.03	0.27	0.16	0.07	0.09
Lime (CaO) ..	0.32	0.15	0.10	0.05	0.09	0.18

Soils on the table-land of Mysore where groundnut is generally grown have the following properties :—

Analysis by Dr. B. N. Iyengar.

Clay	..	7 to 10 per cent.
Silt	..	10.7 to 13.4 ,,
Sand	..	70.4 to 58.3 ,,
Gravel	..	7.5 to 14.6 ,,

They take up 21 per cent of their own weight of water. The optimum water-content of the soil for a good crop is about 60 to 70 per cent of the water-holding capacity. Such a saturated soil has 12 to 14 per cent of water. If the water-content falls below 7 per cent, the crop suffers in growth. Frequent rains and the moisture from subsoil keep the plants going for a long time even if the upper surface gets dry for three or four weeks, and the moisture content falls below 3 or 4 per cent.

Chemical Composition of some Soils.

	Insoluble residue %	Lime CaO %	Nitrogen %	Phosphoric acid (P_2O_5) %
Shallow Red soil ..	91.01	0.25	0.033	trace
Fertile Red soil ..	81.34	0.37	0.052	0.025
Silted soil ..	54.14	1.136	0.043	0.090
Black soil ..	79.62	0.065	0.047	trace
Well manured field sandy loam ..	88.41	0.19	0.081	0.083
Do. ..	86.26	0.21	0.07	0.190

Seasons of sowing are according to the locality, *i.e.*, whether the crop is sown and grown to maturity with the help of S.-W. or N.-E. monsoon. In general, where Mauritius variety is grown, it takes 5 to 6 months to ripen. In the earlier stages for about three months the crop withstands drought very well. After the flowering has started drought seriously affects fertilization and development of pods. Sowings are so arranged as to get the best part of the rainy season for the last 3 months of growth.

Sowings are in July and August for the N.-E. Monsoon zone, April and May or June to September for the rainy zone, and June to August for the high lands where crops are grown with S.-W. mansoon.

Preparation of land.—A thorough ploughing with the indigenous plough is given six or seven times and the land is cleaned. Weeds being very harmful they are removed as often as possible by hand-hoeing or by bullock hoes. The Indian cultivator knows that ground-nut is a very exhausting crop and that it requires adequate manuring and careful cultivation. Tank silt, wood ashes, earth from village ruins or 15 to 20 cart-loads of cattle manure are spread on the field and ploughed into the soil.

For sowing, seeds are bought in shell, shelled by hand and only good seeds are used. Thirty to forty lbs. of shelled nuts are sown per acre. In the south, seeds are dropped 6 inches apart in furrows and covered over by the succeeding furrow. Every alternate furrow is sown. Distance between row to row is about 9 to 11 inches.

In the north of Madras, sowing is done in bamboo drills. Rows are generally a foot apart, and the inter-cultivation is done by using a bladed bullock hoe. Two or three inter-cultivations are generally given to the crop to keep down weeds or to create a mulch after rain-fall. Sometimes crops of sorgum or spiked millet (*Pennisetum typhoideum*) are grown as mixed crop. But this practice interferes with inter-cultivation. In every part details of cultivation vary greatly according to the locality, but in the main they are similar. Before the ground gets hard, when most of the nuts are ripe, men and women loosen the ground with a short bent iron pick called *guddali* and dig the plant from the soil. The nuts are then picked by hand and heaped in a central place. Generally the payment for labour of this sort is in kind. About $\frac{1}{6}$ or $\frac{1}{10}$ of the portion picked is paid as wages. The adjustment is so made that each labourer earns about 5*d*. to 6*d*. a day. According to the fertility of the soil, manuring and irrigation, from 700 lbs. to 5,000 lbs. of pods are harvested; but generally a crop of 1,500 or 2,000 lbs. is considered as a fair crop in irrigated lands. On dry lands 600 lbs. to 1,200 lbs. are considered to be good yields. In irrigated land the cultivation follows the practice adopted for garden crops. Land

is ploughed, clods are broken and the fields are levelled to receive the crop. Groundnut is generally dibbled into the standing crop of a grain some time before it ripens. Fields are kept clean and irrigations are given when there are no rains. At harvest time, if the land is hard, water is run into the fields after all the haulms are cut and removed. The pods ploughed up in the standing water and the floating pods are easily collected. It is this practice that is often responsible for the higher percentage of moisture in Indian seeds. The practice of adding water in order to increase the weight is a rare one. In places where fodder is scarce, much care is taken to collect all the haulms for feeding cattle.

Owing to the shortness of the seasons, in many parts groundnut was not grown till recently. With the supply of such early ripening bunch varieties as small Japan and Spanish, new areas are gradually coming under this crop. Places which had a few acres under groundnut in 1916 have now over several thousand acres. Still there are many tracts in India where groundnut is not known. There is vast scope for growing it in the canal colonies of Sind and the Punjab. If only the oil could be solidified by hydrogenation process as solid vegetable butter, the market in India will be unlimited and there is a great future for groundnut industry in India.

The following table gives the area under groundnut in India in different provinces in 1926. In the black cotton soils of Madras groundnut was never before cultivated ; but now, very large areas are being cropped every year with this crop and there is every prospect of its further extension in that region. And in some localities groundnut has begun to compete seriously with the cotton crop.

	1921-22 acres	1925-26 acres	1929-30 acres
Madras ..	1,459,122	2,598,609	3,209,315
Bombay ..	272,847	595,588	1,067,758
Bengal ..	300	400	500
United Provinces ..	7,589	14,410	23,922
Burma ..	305,789	498,587	570,610
Behar and Orissa ..	200	200	1,200
Central Provinces and Berar ..	15,352	59,686	139,088

West Africa (Senegal Coast).

Soil.—The largest area under groundnut is between the rivers Senegal and Gambia. Latitude 15° N. runs through this part of the continent. Soils in Senegambia are chestnut brown in colour in the north and rich tropical prairie soils in the south. Land is of high productive capacity in Senegal and French Soudan but gradually becomes poorer towards the upper reaches of the Niger near Timbuctoo. Along the coast the soils are either laterites or red loams. Construction of railways and opening river traffic have given splendid facility for transporting the produce to ocean-going steamers. The tract now opened up is only a small fraction of the area in Africa of a similar character which is capable of immense crop production. A study of land and ecological significance yields valuable information indicating the potentiality of regions for crop production. Zones of dry forest with acacia and tall grass savannah land have an agreeable warm weather fit for raising crops of maize, sorghum, millets and groundnuts. There are nearly 885,000 square miles of such land in Africa awaiting improvement and cropping. Of this area about 43 per cent is fit for tropical and sub-tropical crops. What could be done with such soils has been shown by what has been done in this progressive French African Colony of Senegambia.

Groundnut has a growing period of five to six months in this part of Africa.

The following meteorological observations were made at St. Louis :—

Temperature :—

Cropping season	Min.	Max.
June	26.2°C.	29.5°C.
September	26.5°C.	33.7°C.
November	22.9°C.	34.9°C.

Rainfall :—

1904—No. of Rainy days ..	35
Rainfall ..	2981.1 mm.
1905—No. of Rainy days ..	38
Rainfall ..	435 mm.

Humidity :—

January	..	51
February	..	41
April to May	..	61-65
June to November	..	71-75
December	..	61

Physical and Chemical Properties of Senegal Soils from four different places.

Separation by sedimentation		I	II	III	IV
Coarse particles—					
Sand	..	795.928	883.100	843.687	952.400
Calcareous matter	..	0.906	1.000	1.200	1.500
Organic matter	..	0.504	2.300	0.300	2.800
Total	..	797.338	886.400	845.197	956.700
Fine particles—					
Sand	..	92.750	57.000	92.680	21.800
Calcareous matter	..	1.712	2.100	3.623	1.700
Humus	..	4.800	4.900	2.950	2.970
Clay	..	103.400	49.600	55.500	16.830
Total	..	202.662	113.600	154.803	43.300
Chemical analysis—					
Nitrogen	..	0.260	1.100	0.210	0.315
Potash	..	0.542	0.322	0.711	0.305
Phosphoric Acid	..	3.294	0.899	0.575	0.391
Lime	..	1.500	1.850	2.800	1.810

The best quality of nuts are raised on light sandy soils. Nuts raised on alluvial soils are classed as second grades. If a sample contains more than 3 per cent damaged ones, it is re-assorted. A check of this sort has a good influence on the quality of nuts exported.

Cultivation.—Soil is dug up by a crescent-shaped iron spade called *hilare*. Herbage is burnt and the ashes spread over the field. Sowing is done after the first rains in July. Holes 8 to 10 cm. deep are

made with a stick at a distance of 30 to 40 cm. One or two seeds are put into each hole and covered with earth. Sometimes the seeds are soaked for two or three days before sowing. Cotyledons appear above ground in 15 to 20 days' time.

Seed rate is about 100 kg. for a French hectare equal to 2½ acres. The crop ripens between January and February, whereas in North America and India, it ripens in November and December, and in Argentina and Mozambique it comes to harvest in May. A good yield is about 2,000 kg. per hectare or about 1,850 lbs. per acre.

Weight of green leaves per acre ..	2,100 kg.
,, of dry hay ..	1,500 kg.

Leaves contain 1.77 per cent nitrogen and are used as cattle fodder.

The roots smell like liquorice when fresh. Varieties generally grown are both spreading and bunch types. Foreign varieties have been tried by experimental stations and no new one has yet replaced the local types.

In passing, a rapid survey of the various countries may be made.

In Egypt, groundnut is grown on irrigated lands and some fair yields are harvested. In Uganda, Soudan, Eritrea, British East Africa, Tanganyika and Nyasaland cultivation is extending and the methods followed are quite primitive. In Laurenco Marques in Portuguese East Africa good crops are grown on drift sand-dune formations. (Personal information given by Dr. Moss.)

Crops in Java, Burma and China are raised in the same manner as the local grain crops on well-drained soils.

From the brief descriptions given above, it will be seen that the climatic conditions are similar in all the three zones of production. And the soil in each place is either light sandy or light loamy with good porous subsoil. The fertility of the soils varies very much. Soils in the United States are very rich in nitrogen, phosphoric acid and lime; Indian soils are very poor in nitrogen, highly deficient in phosphoric acid and poor in lime. In Senegal the soils are very rich in nitrogen and phosphoric acid. And they are exceedingly rich in lime. So far as potash is concerned, all the soils are similar. Groundnut grower in the United States feels the necessity for manuring with artificials in spite of his having a fertile soil. In India and Africa, no attention is paid to use well-balanced manures. Cattle

manure and ashes are the only manures they have, and even these are not available in sufficient quantities. The following table shows the composition of soils in the three regions under discussion.

	Nitrogen	Potash	Phosphoric acid	Lime
	per cent.	per cent.	per cent.	per cent.
The United States of America	.42 to 1.04	.48 to .91	.41 to .77	.42 to 1.4
Senegal ..	.21 to 1.10	.50 to .70	.39 to .89 and some 3.29	1.5 to 2.8
Madras ..	.008 to .17	.03 to .98 including sodium	.03 to .14	.32 to .05
Mysore ..	.03 to .30	.15 to .41	.19 to trace	.19 to 1.36

Groundnut is very much influenced by external conditions. In a rich fertile soil with a sufficient amount of rainfall, the pods are big and attractive. The same nuts when they are removed to dry tracts and grown in poor soils under deficient rainfall produce small pods. It has been found in Gambia that the same variety of groundnut varies between 23½ lbs. to 28½ lbs. per bushel according to whether the rainfall is less or more than the average.

The table given above shows how poor the Indian soils are in comparison with the others. In spite of this poverty of the soil, by cultivation and irrigation sometimes very heavy crops have been harvested. Groundnut is a very exhausting crop and if a judicious system of manuring is not followed, the soils will deteriorate. The manurial requirements of an average good crop can be judged by the following tables.

The manurial value in a crop taken out of a hectare contains the following amounts of the most important constituents.

Quantities in kilograms per hectare.

	Nitrogen	Phosphoric acid as P_2O_5	Potash as K_2O	Lime
Groundnut with shell 300 k.gms. ..	100	20	28	10.4
or				
Groundnut straw 4480 k.gms. ..	90	12	44	93.2
TOTAL ..	190	32	72	103.6

Calculating on the above basis and making allowance for the nitrogen fixed by the plant the manurial requirements per acre would be as follows :—

Nitrogen	..	24 kilos=52.8 lbs.
P_2O_5	..	17 ,, =37.4 ,,
K_2O	..	36 ,, =79.2 ,,

These figures and the practice in vogue in the United States give practical suggestions for a rational system of manuring. With slight modifications to suit local conditions a working basis may be arrived at with the help of these figures.

Varieties.

There are many varieties under cultivation in different parts of the world. There seems to be a resemblance between all varieties grown in South America, East Indies, old types grown in India and East African types. West African types are distinct ones but resemble some in Brazil. The North American types are big-podded and have thick shells. The present commerical type in India is a variety brought into India from Mozambique through Mauritius. At present various experimental stations have been testing groundnuts got from all groundnut-producing countries and probably the main types are now being grown in almost every country.

A. *United States.*—In the United States of America the following varieties are grown. Many other less known varieties and hybrids are also grown.

(1) *Virginia Runner.*—This has a spreading habit of growth and forms pods both at the base of the plant and along the stems. Bunch Virginia seems to have originated from this. Now the two have become fixed and are classed as distinct varieties. It is difficult to dig out all the pods in this variety and many pods get left behind in the ground.

(2) *North Carolina.*—This resembles Virginia Runner in every respect except that it is smaller in every way, indicating relation to African nut.

(3) *Virginia Bunch.*—This has an upright or bunch habit of growth and the pods are formed in a cluster around the base of the plant. It is easy to cultivate and harvest.

(4) *African.*—This is a low-growing runner requiring a long season to ripen. It produces heavy yields of pods which are fairly high in oil content.

(5) *Spanish.*—This has an upright habit of growth, heavy foliage and the pods cluster round the bases of the plants. It is easy to cultivate and harvest. It is mostly in demand by factories which prepare shelled goods for the market.

(6) *Small Spanish.*—This is a variety or strain of Spanish, pods and seeds are a little too small to meet the market requirements.

(7) *Improved Spanish.*—A number of hybrids or selections from true Spanish are known under the names Improved Spanish, Jumbo, Large Spanish. In these the pods and nuts are larger than the true Spanish.

(8) *Valencia.*—This has a vigorous upright growth with the pods clustered round the base of the plant like the Spanish. The nuts are reddish in colour and not considered desirable for shelling purposes.

(9) *Tennesse Red.*—This belongs to Valencia type. Pods are extremely long and slender with three to seven red seeds in each pod. It is sold for roasting in the shell.

(10) *Georgia Red.*—This is also called Red Spanish. It is closely related to Valencia. Pods are sharp, usually containing two or three light red seeds. It is grown specially for hog feeding.

B. *Costa Rica.*—A variety grown here has long slender pods with many seeds. Probably this variety contains the longest pod of any with the largest number of seeds.

C. In the West Indies and South America, specially spreading varieties are grown. The Argentina type has low oil-content and a resinous matter in the oil. One of the types in Paraguay seems to put forth many flowers at the same time in every leaf axil.

D. *Europe.*—Varieties grown in Spain are mostly the Valencia type.

E. *Africa.*—(1) On the West Coast both erect or bunch and spreading types are grown. The pods and seeds are small but the oil-contents are higher than in American nuts.

(2) In Rhodesia, long, slender-podded varieties with three or four red-seeded pods are grown. They are similar to Valencia.

(3) In Transvaal, varieties grown are like those of Portuguese East Africa.

(4) *Mozambique.*—This is the variety grown in Portuguese East Africa. It is a vigorous plant producing seeds with high oil-content.

(5) Egypt.—The following varieties are grown :—

(*a*) *Sudani, beladi or behari.*—These are small compact nuts to those of Senegal.

(*b*) *Madrasi, Hindi, Afrangi or Nabarissi.*—These types are from Madras similar to or same as Mozambique.

(*c*) *E. Huri, Khouri, Fransawi or Roumi.*—These nuts are similar to Mozambique but the origin is not known.

(6) Plants from Madagascar seem to be similar to those collected in Java and Mexico. They have shaggy hairs and violet tinge in the stem.

F. (1) *Asia.*—The old types grown in India are now represented by the Mysore Local. It has a very thin slender-shelled, long pod having 3 to 5 or 6 wrinkled seeds in a pod. Plants have pale-green leaves with hairy stems. The violet tinge in the stem is similar to that of plants grown in Mexico, Java and Mozambique.

(2) *Mozambique.*—It is now grown in Madras as Mauritius.

(3) *Small Japan.*—It has an upright growth having all the pods at the base of the plant. It has a thick shell and the pod contains one or two round red seeds. The leaves are pale yellow in colour.

(4) *Big Japan.*—This is a trailing plant, having big pods with many three-seeded pods. The shell is very thick.

(5) *Spanish.*—It is like the Small Spanish of America, having small round two-seeded pods. It has a pale-yellow leaf. All pods are borne by the upright plant near its base.

(6) Barbadoes, Carolina, Transvaal, Senegal, Brazil are all imported nuts. They are being tested in many places. They all resemble the nuts in their respective countries. But many of them are getting mixed up.

Java has begun to introduce many new types.

China and Japan have both upright and spreading plants.

Philippines :—They are growing all the American types.

G. *Australia* has imported all new American types.

Pests.

A number of insects attack the plant. All parts of the plant have some enemy or other—caterpillars eating leaves, blister beetles destroying flowers and buds, and white-ants damaging roots and nuts. But the most serious insect pests in India are two :—

(1) *Sural puchi* or leaf roller. *Aproœrema nerteria* (Meyr).—It is a small moth with hairy wings. Eggs are laid on shoots and leaves. They hatch in 3 or 4 days. A minute greenish caterpillar which comes out of the egg burrows into the leaf of the groundnut. At this stage of attack the foliage becomes yellow and spotted. A few days after the caterpillar comes out of the leaf, webs together a number of leaves and feeds on them. It is at this stage the insects are most harmful. After binding several leaves and destroying them for three weeks the caterpillar enters the chrysalis stage. Four days after, the moth emerges. So far no remedy has been discovered. Light traps have not been a great success. The loss caused by this insect is very great in some years.

(2) *Kambli puchi. Amsacta albistriga* (Wlk).—This is a hairy caterpillar which does immense damage after the rains have set in during the S.-W. monsoon.

The moth has white wings with brown markings. The abdomen is banded black and yellow. Hundreds of shining yellowish white eggs are laid in groups on different plants. Eggs hatch in a week. Caterpillars go in numbers over the fields and eat the leaves of the crops.

Generally they are found between June and September. Each caterpillar grows to about $1\frac{1}{4}$ in. in length in 40 days and then pupates in the soil at 4 or 5 inches from the ground surface. They hibernate in the soil for several months and emerge as moths after the first rains in the next season.

To destroy the swarms of caterpillars is beyond practicability. During summer, by deep ploughing the pupæ are turned up and exposed to the air. Natural enemies like crows and lizards destroy them. Children of the villages in the affected areas in Mysore have been trained to spot these moths by means of practical demonstrations and coloured charts. A small reward is paid to them for collecting these moths when they appear in the fields after the first rains

in May and June. The moths are slow and easily caught. Several thousands are destroyed in this way, year after year, and the pest has been kept under control in several parts. Funds for paying the collectors are raised by each village. The whole village takes part in the campaign against the pest. "Pest Acts" which have been passed in different provinces of India in recent years, compel the slackers to take part in the campaign or pay for default. So far the scheme has worked well and the results have been beneficial.

Red ants sometimes injure the roots and fruiting stalks. White-ants or termites do great damages specially in droughts. The pods are attacked under ground by species of *Pseudococcus* (cœcidæ) in Mysore.

Grass-hoppers—*Orthacris* Sp and Sp of *chrotogonus*—eat the leaves. Beetles—*Zonabris pustulata*—destroy flowers. Grub of beetle—*Sphenoptera arachidis*—burrows in the stem, but it is not a serious pest.

In lower Egypt, the cotton worm—*Prodenia litura*—is said to be very destructive when it is present. It is a Lepidopterous pest. A yellow aphis sometimes appears but is not severe.

Diseases.

The common leaf disease is known as "tikka" (*Septoglœum arachidis*) in Bombay and *Simbai rogum* in Madras. It is responsible for great losses in some years. The small spots grow, join together and form large discoloured areas. The leaves turn yellow and fall to the ground. If the attack is early, the nuts do not ripen, and the pods contain only shrivelled-up seeds. No satisfactory remedial measures have been found. Vigorous types seem to withstand the disease well and some of them are said to be more resistant than others. This disease seems to occur in almost all countries.

Sclerotium rolfsii is often met with in West Africa.

Cakes and seeds are attacked by fungi and bacteria in the stores and ships especially, when they are moist. As a result of their action fermentation sets in and the material gets rancid. Such samples have no value in the market. This complaint applies specially to the decorticated nuts exported from India.

The Rosette Disease of Pea Nuts.—

In the rosette disease there is a striking modification of the plant. It becomes a close tuft of small curled leaves forming a

cushion of a few inches diameter or its branches may be of some length, but bear, terminally, tufts of small leaves. Yellowing usually gets distributed over each young leaf, but it is occasionally confined on each leaf to irregular areas, separated by normal green tissue producing a mosaic-like pattern.

Zimmermann, in 1907, attributed the cause to a virus. Storey and Bottomley have shown now that the disease can be transferred by grafting and by insect vectors. The aphis that transfers the disease is said to be *Aphis leguminosæ*. Both the winged and wingless forms are responsible for this transfer.

This disease has been noticed in Java, India and in the United States of America. It was noticed in Java in 1908 in a sporadic form. It has been also found on six other legumes and four non-legumes. But it is very destructive in South Africa.

Destroying all winter plants and discovering resistant varieties seem to be the only remedies. Slime disease, *B. solanacearum*, in the Dutch East Indies; Rust, *Puccinia arachidis*, in the United States and in S. America and Redrot due to *Neocosmospora vasinfecta* in the United States are some of the common diseases on groundnut. These are not causing much damage in India.

During the last five years in Mysore, in some seasons, very large percentage of unfilled pods have been noticed. In such pods we find seeds in all stages of development. A species of Fusarium seems to be the cause. Work is in progress to identify the fungus and to discover remedial measures. Selection of well-developed seeds only for sowing seems to reduce the ill-effects of this fungus. In 1926, in one sample 90 per cent were affected. By seed selection the attack was reduced to about 50 per cent in 1927. Selected seeds from these contained only 6 per cent of diseased nuts. Treating the seed in solutions of corrosive sublimate and in formalin are in progress.

SELECTIONS

No Loss of Moisture by Capillarity in our Dry-Farming Areas

By H. C. Stening

Chief Instructor of Agriculture

For many years it has been the opinion of agricultural scientists and experts that a loose, dry soil-mulch was effective in preventing loss of moisture from the soil, by checking the rise of the soil moisture to the surface. It was held that water was capable of rising in the soil by capillary action and thus reaching the surface, where it was evaporated unless prevented by means of a mulch, but research in recent years tends to show that the upward capillary movement of soil moisture is effective only over short distances, and it is only when the ground-water level is within about 6 feet of the soil surface that moisture can rise to the surface.

Under dry farming conditions there is consequently no loss by capillarity, and therefore a soil-mulch in itself is of no value in checking the loss of soil moisture. This fact, however, does not materially reduce the importance of the cultivation of the fallow, as it prevents loss of moisture through weeds, which are great robbers of soil moisture. Furthermore, the maintenance of a loose, coarse, granular mulch will allow rains which fall during the spring and summer to sink into the soil readily, instead of running off or being held near the surface to be rapidly evaporated.

There are other benefits to be derived from the cultivation of the fallow apart from conservation of moisture. For instance, the aeration of the soil promotes the development of soil bacteria, which results in increased production of nitrates, and, moreover, one of the chief advantages of a cultivated fallow is the preparation of a good seed-bed, which ensures a ready germination and vigorous early growth of the crop. As a result of the compacting of the seed-bed the amount of moisture per unit volume of soil is increased, with the result that the young roots of the crop can obtain the moisture more easily.—*Agricultural Gazette of New South Wales*, Vol. XLIII, Part 10.

Grafting *versus* Seeds in Coffee

By Ferwerda, F.P.

Serious attention in Java was first paid to the grafting of coffee in 1896. It was regarded as a possible way of escape from eelworm attack then very severe on Arabica coffee. The stock used was *C. liberica*, a species which is comparatively immune. Interest in grafting waned, however, with the introduction of Robusta coffee, which is quickly raised from seed and has considerable immunity to various diseases. At the present time, for one reason or other, grafting is again coming to the fore and the lecture is concerned with a discussion of its merits and demerits as compared with the usual method of propagation by seed. Advantages of grafting are :—Uniformity in growth and habit, less variability in yield as between individual trees. (A diagram* is given to show that in a certain seedling plantation under investigation, 75 per cent of the total yield was supplied by 47 per cent of the total number of trees. It took, therefore, 53 per cent of the total number of trees to supply the remaining 25 per cent.) The ripening period is more defined in grafts than in seedlings, a fact which leads to economy of labour in harvesting and to control of diseases and pests attacking the berries ; the possibility that by means of highly resistant root-stocks plantations can be laid out on infected land ; the possibility of perpetuating a desirable variety without the mutations of seedlings. The power to transform a poor orchard into a better one by top-working the existing trees. Dealing with comparative yields it is shown by diagrams that, while seedling crops fluctuate from year to year, those of comparable grafted plantations are more regular ; nevertheless, over a period of years the average yield of the grafts is considerably, *i.e.*, 60 per cent, lower than that of the seedlings, even when the grafts are taken from particularly good parent trees, while the compared seedlings are from unselected stock. A discussion on the reason of this phenomenon follows.

A series of experiments in pollination revealed that Robusta coffee was self-sterile. It became obvious, therefore, that large plantations of grafted plants derived from a single clone would be naturally intersterile. This conclusion was emphasized by the fact that the boundary trees of grafted plantations, where those plantations joined others of different descent, would bear well, while the interior of the plantation would have but a poor crop. An instance is then given of plantations containing grafted plants interplanted either with seedlings or grafted plants from different clones, and these bear as well or better than a comparable seedling garden. The conclusions drawn are :—1. The laying out of large single-clone plantations is inadvisable. 2. Productive grafted plantations can be made by interplanting different clones or by leaving groups

* Diagram omitted in this Journal.—Ed.

of seedlings standing in the case where an existing plantation is top grafted. 3. It cannot at present be asserted that grafted plantations will yield more than seedlings, but the advantages of uniformity in various directions coupled with the fact that the produce usually commands better prices makes the method worth while. 4. Certain hybrid varieties, which are particularly fitted for districts where the standard sorts do not flourish or which have other desirable qualities, can only be propagated by grafting.—*Plant Breeding Abstracts*, Vol. III, No. 2.

The A. I. V. Process of Conserving Green Fodder*

In these days of economic nationalism and of devalued currency in terms of gold, it is a cardinal principle to produce as much at home as natural conditions allow. Although only the Dr. Panglosses believe that Great Britain could feed her people entirely and adequately from her own resources, yet all who have studied the question think that we could go a long way towards this goal. Great Britain, for example, is one of the most favoured nations in regard to grass production, yet it imports many million pounds' worth each of butter, cheese, eggs, meat, and concentrated feeding stuffs which could be produced at home. The annual bill for imported concentrated foods is so high that efforts have been made recently to dry artificially the young, protein-rich grass and so conserve it for winter 'keep'. Up to date, experiments made with this object in view in Germany and Great Britain have failed to bring conviction to the economist, and it now looks as if the desired end is to be achieved by a modification of the old practice of ensiling. The ensiling of green fodder crops for use as winter 'keep' has made great headway in New Zealand, the United States, Holland and Germany, but the English farmer has been slow to realize its advantages. However, he has now an opportunity. Thanks to the enterprise of Imperial Chemical Industries, Ltd., a new chemical method of ensiling, which hails from Finland, has been launched in Great Britain, large-scale experiments having been undertaken at the company's research station at Jealott's Hill, Berks, and at various other places.

When ensilage is made in the ordinary way, in tower, stack, or pit, the green fodder undergoes various changes, due to enzymes and bacteria, which usually entail a loss of 15–30 per cent of its nutrients, and much more if any thing goes wrong with the process. In the new Finnish process—called the A.I.V. process, after the initials of the discoverer, Prof. A. I. Virtanen—such changes are inhibited by maintaining the fodder at a hydrogen-ion concentration of 3-4. This

* The conditions obtaining in this country are different from those in the countries mentioned in the note. It seems to us worth the while that small-scale trials should be conducted here. For one thing, the cheap labour available here should enable us to produce the silage at less cost than elsewhere.—Ed.

is achieved by spraying a dilute acid liquor on to the green crop as it is charged into a pit silo ; and mould growth is prevented by spraying the top layer with an anti-mould preparation, called " Homesurma " (mould death). The composition of the acid liquor is not revealed, but it is stated to consist mainly of hydrochloric acid, whilst ' Homesurma ' is said to consist chiefly of allyl mustard oil. When the pit is fully charged, it must be sealed on the top as tightly as possible, for example, by means of sacking covered with clay or loam, as ingress of air is fatal to success. According to Prof. Virtanen, A.I.V. fodder contains a much higher content of digestible protein than ordinary silage; and he estimates the loss of nutrients in the preparation to be 0.2 per cent from respiration, nothing from decomposition of proteins, and 1.3 per cent from escaped juice.

The A.I.V. process has achieved remarkable success in Finland, where it has been taken up by the butter co-operative export society, Valio, which controls 90 per cent of the butter exported from that country, in 1927 and 1928 : the process was being worked out and tested mainly in the laboratory : in 1929, it was used on 3,000 farms, and 30,000 metric tons of A.I.V. fodder was produced ; in 1931, 100,000 tons was made on approximately 10,000 farms : and in 1932 the process is being used on 13,000 farms. All kinds of green crops have been ensiled, but legumes or young grass are best for feeding to milch cows.

The ordinary winter ration used in Finland for 800-gallon cows consists of concentrates, turnips, hay and straw ; in the A.I.V. ration, all the turnips and much (in some cases all) of the concentrates are eliminated together with much of the hay. Expenditure on imported concentrates has been reduced by 50-80 per cent, and at the same time the milk yield has increased. The animals readily eat the fodder, ensiled grass being preferred. The free acid is said to disappear before the fodder is fed, but on most of the Finnish farms using the process a small amount of chalk is included in the silage ration. It has been found that the animals do not tire of A.I.V. fodder, and that their general health remains excellent : the distribution of lime and phosphorus in the teeth and bones, and of lime, phosphorus and chlorine in the muscles and blood, remains normal. The quality of the milk resembles that of summer milk, both the butter-fat and protein contents being slightly higher than when the cows are fed on the ordinary winter ration ; and the butter made from winter milk lacks its usual brittleness owing to the oleic acid-content being maintained at summer level. Further, the high vitamin content is held to be of great importance to public health as the majority of the inhabitants of northern countries rely mainly on milk and milk products for their supplies of vitamins A and D, and hitherto it has been found that the growth of children in Finland is practically confined to the months from July to December.

The only capital cost involved is that of making the silo pit, which has a diameter of 16½ feet and a depth of 4 feet 9 inches. In Finland, where family labour is abundant and wood is cheap, this cost is very low. Unless the subsoil is chalk, the pit must be lined with wood, or with cement if there is danger of water seepage. A light wooden superstructure, which is transferable from pit to pit, must also be provided; it is placed over the pit when the green material reaches the ground level, and filling then proceeds until the superstructure is also full. The fresh material is then weighted, in a day or two it sinks to the ground level, and the superstructure is removed. Working costs vary with the crop ensiled, the yield per acre of the crop, and with the cost and efficiency of the labour. With labour, as in England, at about 8*d*. per hour, the cost per ton of dry matter (about twenty per cent of the green weight) is estimated to be about 22*s*. 6*d*.; if to this figure we add £ 2 per ton of dry matter as the inclusive cost of growing grass for ensilage with the aid of manures, we obtain a total of £3 2*s*. 6*d*. per ton, to which must be added a further small sum for cost of acid and depreciation of the silage pit.

Large-scale trials of the process are being made in Denmark as well as in Great Britain; in addition, the process has found a footing in Sweden and Norway; whilst in Germany, where some of Prof. Virtanen's claims are contested, the process, in its essential principles, has been officially adopted and is being widely advocated. If found to be a success in Great Britain, the adoption of the process will not only save the country millions of pounds per annum on imported concentrates, but will also provide what appears to be the only practical, economic solution of the problem of utilising flush growth of grass, which is one of outstanding importance in the management of grassland.—*Nature*, Vol. 130, No. 3290.

Poultry Keeping

By V. Venkatasubbaiya
Member, Servants of India Society

Poultry keeping is an important branch of agriculture in the Western countries. It perhaps lends itself to co-operative organization as much as, if not more than, any other branch of agricultural business. The organization on co-operative lines of the production and sale of eggs in Denmark has become a classical example to co-operators all the world over.

There is much scope for the development of poultry keeping in India which is believed to be the original home of the cock. The Government of the United Provinces has started a school for teaching the subject and many educated Indians have started private farms of their own, after undergoing training there. Several missionary organizations are maintaining efficient poultry farms and are training members of their congregations to the occupation. In the Rural Reconstruction Centres

of the Y.M.C.A. poultry farms are maintained and the subject is taught to batches of students in successive summer schools. All the educational efforts are based on the belief that poultry keeping on improved lines can be developed in our country as a secondary occupation for the agriculturists.

It is true that as in every other kind of business,—agricultural or other—theoretical knowledge alone does not suffice and that it has to be supplemented with the knowledge that only experience can give. Without sufficient previous experience no one may expect to run a poultry farm successfully. That experience can be easily acquired by any willing agriculturist, who sees the profitableness of the occupation.

We hope that the particulars given below of a poultry farm owned and successfully managed by a prominent co-operator will be found inspiring to other co-operators in our province. The farm is at Sanankuppam, a hamlet of Ambur with a railway station in North Arcot District on the Madras-Bangalore line. The owner is Mr. Manikya Mudaliar, President of Ambur Land Mortgage Bank and of the Ambur Supervising Union. It is in charge of his son-in-law Mr. S. V. Swami, who received training in poultry farming in May 1930 at the Rural Reconstruction Centre of the Y.M.C.A. at Ramanathapuram in Coimbatore under its poultry expert Mr. T. Stephen. In June 1930, a small beginning was made with white Leghorn cock and two hens of the same breed brought from the Ramanathapuram Rural Reconstruction Centre. During the first two years, attention was concentrated on increasing the stock. In the first hatching season, from 12th August 1930 to 13th April 1931, the hens laid 250 eggs of which 180 were successfully hatched and 70 were spoiled. In the second hatching season 806 eggs were laid by the original hens and the new stock, of which 664 were successfully hatched and 142 were spoiled. In the third hatching season, commencing with 1st August 1932, no hatching is attempted, as the owner considers the farm to be fully stocked. The eggs are therefore being sent to Madras for consumption. They are being sold at Re. 0-12-0 per dozen which leaves a satisfactory margin as profit.

Out of 844 chickens successfully hatched in the last two years 100 birds and chickens died of disease and 38 of accident ; 526 were sold and 180 were in the farm on 23rd October 1932. These latter consisted of :

		Rs.	a.	p.
100 hens valued at		300	0	0
33 pullets		66	0	0
26 breeding cocks		52	0	0
21 cocks in reserve		21	0	0
180	Total ..	439	0	0

The income and expenditure for the whole period 7th June 1930 to 23rd October 1932 is given below:

Income.	Rs.	a.	p.	*Expenditure.*	Rs.	a.	p.
By sale of eggs ..	435	12	11	Fowls purchased ..	12	8	0
By sale of fowls ..	493	11	9	Feeding charges ..	577	13	3
By sale of droppings ..	34	0	0	Establishment ..	85	8	0
				Medicines ..	41	5	7
				Miscellaneous ..	9	13	2
Total ..	963	8	8	Total ..	727	0	0

To the figures given above must be added on one side the value of the stock and on the other side interest on the capital spent on fencing, structures, incubators and other appliances, depreciation and rent. These charges are not all accurately ascertainable, because the land and structures are intended and used for other purposes as well as for poultry keeping. What perhaps is quite sufficient for our purposes is that with the present stock the farm is giving a current income of Rs. 40 to Rs. 50 per month in excess of the current expenditure.

With the experience he has gained on his own farm, Mr. Manikya Mudaliar should soon be able to organize a Co-operative Society for production and sale of eggs from his area. From a co-operator of his position and enthusiasm the formation of such a society is certainly to be expected. In such pioneering effort, we are sure that the North Arcot District Bank and the North Arcot Council of Supervision will only be too glad to co-operate as also the Provincial Co-operative Union and other bodies in Madras, if only they are told what help is needed of them.—*The Madras Journal of Co-operation*, Vol. XXIV, No. 7.

Practical Immunization of Plants by Genetic Methods

By N. Von Gescher

It is an established fact that prevention is better than cure, and it is difficult to imagine a more completely preventative measure against the diseases and enemies of plants than the use of immune varieties. This method is all the more advisable during this period of crisis which calls for economy on all sides. It is therefore natural to find in phytopathology a diminution in the use of chemical products and all other costly methods, and on the other hand an increasing tendency throughout the world to adopt the cheap and simple method of immunization, as soon as suitable varieties are created.

A distinction must be made between acquired immunity and innate immunity. The first, which is of immense importance in human and

veterinary medicine, but has, up till now, been considered of no practical value with regard to plants, has aroused considerable interest owing to the labours of Carbone and Arnaudi (Milan). These authors have actually proved that plants can be successfully inoculated against pathogenic micro-organisms. They have several times been able to increase the resistance of a plant to a given fungus by preliminary treatment with more or less virulent cultures or extracts of the same fungus. This artificially produced resistance, however, lasts only about three weeks at a time. The observations and experiments made by Montemartini on the oidium of the oak, however, give reason to the hope that there are cases in which acquired resistance may last longer. These cases would be suitable for the practical application of inoculation. Besides this, certain diseases, such as bunt of wheat, only attack the plants at a certain stage of development, often during a very short period. It would then be enough to immunize the plant during this receptive period, which would appear to be practicable.

Undoubtedly, acquired immunity, especially by inoculation, can never be of such practical importance in the vegetable world as it is in the animal kingdom. The contrary is true of innate immunity. This has, up till now, played only a secondary role in animal husbandry. Only quite recently has it become known that experiments begun in 1924 with the cross-breeding of wild boars and improved domestic pigs have been successful in producing a race of pigs resistant to swine plague by combining the immunity of the boar with the good qualities of the pig which served as mother.

On the other hand, innate immunity is of very great interest with regard to plant selection. The researches of Biffen and Nilsson-Ehle have shown that hereditary resistance is transmitted according to the Mendelian rules. In the simplest cases resistance is determined by one dominant factor which will produce in the second generation 1 susceptible individual to 3 resistant. This has been verified by Hubert who crossed Peragis spring wheat with Normandy wheat, which latter is resistant to rust. But the case is often more complicated. Zeiner, for instance, crossed " Walpersii " barley resistant to loose smut (*Ustilago nuda*) with another variety, the " Heils Franken ", of high value but non-resistant to smut. Here also the resistance seems to be dominant. However, the vigour with which it is manifested depends on three factors which transmit independently and which produce in the descendants variation from complete resistance to complete susceptibility. The same holds good for the resistance of the potato against *Phytophthora infestans*, which likewise depends on a whole series of factors. Resistance is not shown unless the combined effect of these factors passes a certain limit. The case becomes still further complicated if several different biologic

strains of the parasite are present. In order to obtain resistance the plant breeder must then combine in his products all the individual factors causing resistance to the various biologic strains of the parasite. Where there are, for instance, 60 different strains of the parasite, as in the case of wheat rust, the task may appear well-nigh impossible. However, Schreiber has shown in dealing with anthracnose of the bean (*Gloeosporium Lindemuthianum*), that it is possible to obtain immune varieties although there are 34 biologic strains of this fungus. He has been able to divide these forms into three groups : A, B and C, to which correspond three different independent factors guaranteeing immunity against the corresponding group. By infecting the F_2 generation of a cross between a susceptible and a resistant variety with one of the groups (A, B or C) of the biotypes of the fungus, he obtained a segregation of susceptible to resistant in a proportion of 1 : 3. By infecting with two groups at a time (A+B, A+C or B+C) the result was 7 : 9 corresponding to a two factorial segregation. An infection with all the groups at once (A+B+C) gave a three-factorial segregation ; susceptible 37 ; resistant 27. In the F_3, out of a total of 288 lines of descendants, 5 were found to be homozygotes resistant to all the biologic strains of the fungus.

It goes without saying that such varieties, having undergone so severe a trial, are far more likely to resist still other biologic strains which might appear later.

In practice, selection for resistance depends very largely on the manner in which the test is made. Observation in the field is not enough as the element of chance is too strong (soil conditions, weather, specific climatic conditions within the crop itself, etc.). It is necessary to use artificial infection and to make observations in the laboratory. There are available simple and well-tried methods of dealing with potato wart disease, rust of cereals and potato *Phytophthora*. The method of artificially infecting barley with *Ustilago nuda* is also good but difficult. If a correlation between immunity and some morphological or anatomic character could be found, the work of selection would be greatly simplified. In this regard, Longeree's work on the correlation between the resistance of the potato to wart disease and the plant's aptitude to produce callus tissue should be mentioned.

The very nature of the immunity of plants is as yet little known : it is, however, of great interest for the plant breeder to learn the mechanism and to know, for instance, if the immunity of a given plant is *active*, arising from a defensive reaction of the plant itself (such as the formation of layers or cork cells), or if it is *passive*, due to certain qualities (hairs, structure of the epidermis, acidity of cell sap, etc.) which render it immune from the attacks of micro-organisms. Quite recently Ezekiel

has been able to prove that the resistance of some species of plants to root rot (*Phymatotrichum omnivorum*) is dependent on the presence and the concentration in the plant of certain specific elements which hinder the development of the fungus. The resistance of onions to smut J. C. Walker has shown to be dependent on the presence of protocatechuic acid.

Selection by cross-breeding cannot be begun unless strains known to be resistant are available. It is therefore necessary to obtain the largest possible assortment of varieties. In order to remedy the poverty of genes in our cultivated plants, which have lost part of their valuable genes during the centuries in which man has been gradually bringing them from their centres of origin (Vavilov) to their present places of cultivation, it is sometimes necessary to return to the wild varieties for crossing with the improved species. The resistance determining factors if not found in our cultivated plants can be discovered in the wild and primitive varieties. In testing the descendants of a cross between a wild and a cultivated species for resistance the susceptible forms are easily eliminated. The main difficulty consists in afterwards eliminating the undesirable qualities which will have been introduced by the wild species. To do this it may be necessary to cross several times with a cultivated variety, testing each time for resistance. This laborious work must be carried on throughout several generations of the plant, usually entailing a like number of years. It is therefore fortunate that the researches of T. D. Lyssenko (Odessa) have resulted in the perfection of a process which will reduce the ordinary length of the work of selection to a half or even to one-third. This process, called by the Russians (iarovisation) consists mainly in treating seeds with high or low temperatures. Seeds thus treated develop rapidly from the vegetative to the reproductive stage. Moreover, if the duration of light is artificially regulated so as to influence favourably the phytoperiodicity of the plants in question they will complete their growth cycle in a much shorter time. Iarovisation is practised in the U.S.S.R., both for selection and in ordinary agriculture, and it would appear to be acquiring great value for grain cultivation in dry climates.

The practical examples mentioned above prove that it is possible by selection to arrive at varieties which combine with their other qualities the faculty of resistance to disease. The Americans have been very active in the practical application of immunization by selection. As far back as 1908 W. A. Orton was able to produce in South Carolina varieties of cotton and melon resistant to wilt and a variety of rust-resistant wheat. Since that date scientific research and practical experiment have advanced every year. Experiment stations in different States of the Union, amongst which that at Minnesota takes first place, have

produced varieties of ever-increasing resistance, particularly of rust-resistant wheat. To-day, resistance to disease is everywhere the main purpose of numerous experiments in plant selection. We have already mentioned the work recently done at Halle on these lines. We must add to this the research on cereal rust done by the Biologische Reichanstalt (Dahlem) in collaboration with Professor Gassner (Brunswick), and that of R. H. Biffin (Cambridge) and Nilsson-Ehle (Sweden). Satisfactory practical results have been attained in British India with the creation of a variety of barley resistant to *Helminthosporium sativum*, in Japan with the creation of a rice resistant to *Helminthosporium oryzæ*, *etc.* Of late years the most exclusive demonstration of selection with an aim to immunization was the creation of the sugarcane variety P.O.J. 2878 by J. Jeswiet (Dutch Indies). This variety, which combines with almost complete immunity against mosaic and sereh, a quite extraordinary productivity, has, within a few years, supplanted all other varieties grown in the Dutch Indies. It is, thanks to this new variety, that the sugarcane cultivation of those countries has been able to compete successfully with beet sugar growing.

The selection of immune varieties still raises many problems and possibilities. Practical agriculture may still derive many benefits from it, just as was the case in the cultivation of the vine on phylloxera resistant stock which was the salvation of French viticulture at the end of the 19th century. One of the most urgent problems to-day is the creation of direct producers resistant to phylloxera. Another problem is that of the creation of a bunt-resistant wheat. Realization is in sight. There are many other problems of which the solution will gradually be reached. Often a new resistant variety may be of only local or temporary value, but these limitations apply to almost all new varieties and must not be allowed to hinder the progress in the right direction which has already led to such happy results. It is, however, necessary to enter a protest against articles in the daily press which are apt to mislead the uninformed public by raising too great expectations and which do not lay sufficient stress on the great difficulties and the immense amount of patience entailed in the work of the plant breeder.

In order to strengthen the scientific bases of the selection of resistant varieties, there must be close collaboration between plant pathologists and geneticists, a collaboration which should have no national boundaries but should, on the contrary, embrace the whole world. It is to be noted with satisfaction that, in the case of rusts, collaboration is being effectively realized between Germany, the United States and Uruguay, and it was with a view to intensifying this spirit that the General Assembly of 1931 of the International Association of Plant Breeders recognized the Biological Institute of Berlin-Dahlem as the international centre for research on the biological strains of rust.

An international agreement should be made whereby the plant breeders' produce would be put under legal protection throughout the world, rendering it impossible for any country to refuse to export new and valuable varieties, as has occurred in the case of some disease-resistant species.

If world agriculture is to make real progress it is necessary that all innovations should be communicated as soon as possible and that all progress made should be put without restriction at the disposal of all the members of that large family which is formed by the agriculturists of the world.—*International Review of Agriculture*, Year XXIII, No. 8.

Green Manuring of Paddy

By L. Lord, M.A.
Department of Agriculture, Peradeniya

The application of green leaves and of green herbaceous plants to paddy fields has been practised in certain districts in Ceylon for many years but the number of acres annually manured in this manner is small. Definite green manure crops like *Crotalaria juncea* are not grown on the paddy fields in readiness for a succeeding crop of paddy ; only the green leaves of trees and the herbaceous plants found near the fields are used. Many varieties of plants are utilised, including *keppitiya* (*Croton lacciferus*), *pila* (*Tephrosia purpurea*) and *peni tora* (*Cassia occidentalis*). Among the trees whose leaves are used are tamarind (*Tamarindus indica*), margosa (*Azadirachta indica*), kaduru (*Cerbera adollan*), palmyra (*Borassus flabellifer*), dadap (*Erythrina lithosperma*), *Gliricidia makulata*, and *telkekuna* (*Aleurites triloba*). The list is by no means complete and any form of green material may be used. The wild sunflower (*Tithonia diversifolia*) which grows luxuriantly and is found wild in the mid-country makes an excellent green manure and its use is thought to be extending. The green material is applied either before the first or second ploughing and generally in relatively small amounts.

The effect of applying green manures to paddy varies according to the different conditions under which the crop is grown in Ceylon. It may be said to be invariably beneficial although where a loose soil overlies a porous subsoil the addition of large amounts of green matter may militate against the formation of the good puddled condition of the soil necessary to retain in the field the irrigation water. Such conditions will rarely be found. Generally the effect of green manuring will depend upon the amount of weed growth present on the paddy field prior to the preliminary cultivation and this in turn depends upon the water supply (either direct or indirect) and largely on the length of time the land is fallow between two crops. This period may vary from less than a month

to as much as eight months. Where water is available for a short period and for one monsoon only (which frequently happens in the North-Central Province) one three-months', or at the most four-months', crop is all the land will carry for the whole year. During the seven or eight months' fallow there is generally sufficient rain to produce a vigorous weed growth. The application here of additional green material brought from outside will not produce the same effect as in districts where the weed growth is much less or where it may be entirely absent. At Peradeniya, for example, the *maha* crop is on the ground for about 200 days and the *yala* crop for 120-130 days. Preparation of the fields takes up the remaining time and at ploughing only the paddy stubble and the few weeds which have survived among the paddy plants are incorporated in the soil. Experience has shown that under these conditions (if both crops are grown during the year) the fields can only be maintained by manuring. The villagers frequently forego the *yala* crop in order to ensure a good yield for *maha*. Under these conditions the effect of applying green material is large.

The principles and the advantages of green manuring under ordinary conditions and under the anærobic conditions in which swamp paddy is cultivated have been dealt with in Section I. Any but practical considerations will be mentioned here only briefly.

The effect of applying green material to paddy is normally to increase the yield. This is due to increasing the available nitrogen in the soil and also, it is thought, to supplying carbon dioxide to the algal film found on all paddy fields. The decomposition of the organic material may also have other effects on the chemical and physical condition of the soil and on the soil micro-organisms.

Under anærobic conditions the decomposition of green materials produces, among other things, ammonia and carbon dioxide. It has been shown by Kelly and other workers that swamp paddy takes up its nitrogen mainly in the form of ammonia. The anærobic decomposition of green material, then, directly increases the supply of that form of nitrogen useful to the paddy plant. The other effect of the decomposition of organic matter under anærobic conditions which will be dealt with here is that due to the production of carbon dioxide.

It is stated by Brizi that the roots of rice are not of the true aquatic type and he has shown that oxygen is essential to their growth. The algæ which are found as a film on the surface of paddy fields (Esmarch has pointed out that algæ are found in the lower layers as well as in the surface soil) liberate oxygen and require for their existence carbon dioxide. The oxygen which is liberated is believed to be carried to the roots of the paddy plants dissolved in the irrigation water (Harrison and Aiyar). Brizi was the first to point out the significance of algæ in the æration

TABLE I.

Green Manure Experiment (a), *Nitrogen Determinations.*

Upper figures—Mgms. of nitrogen as ammonia in 100 gms. of soil at 100° C.
Lower figures—Mgms. of nitrogen as nitrate in 100 gms. of soil at 100° C.

	Before puddling.				After puddling.							
Time of sampling in weeks.	2	4	6	7	1	3	5	7	9	11	13	17
Control	1.5	2.1	3.0	3.23	1.22	1.73	1.31	1.05	.91	.88	.73	.27
	.55	.96	.75	..	..	..	..	..	..	..	..	..
Green manure (*late*)	..	..	..	..	2.69	4.79	4.30	1.87	1.69	1.30	.87	.96
	..	..	..	..	..	..	..	..	..	..	..	..
Green manure (*early*)	3.4	3.7	5.2	5.8	1.85	2.13	2.13	1.36	1.16	1.05	.83	.63
	.37	.70	.78	..	..	..	..	..	..	..	..	..
Weeds (*late*)	..	..	..	..	2.14	3.06	2.50	1.41	1.42	1.37	1.25	.70
	..	..	..	..	..	..	..	..	..	..	..	..
Weeds (*early*)	1.4	1.6	2.7	3.0	2.02	2.36	1.89	1.27	1.08	1.04	.63	.44
	.45	.55	.45	..	..	..	..	..	..	..	..	..

TABLE II.

Green Manure Experiment (b), *Yields of Grain.*

Treatment.	Calculated yield per acre mean of 4 plots of 1/100 acre. lb.	bus.	Control—100.	Value of increase over control at Rs. 2—50. per bushel.
				Rs.
Control	2,482	59	100.0	....
5 tons green manure (*early*)..	3,318	69	116.7	25—00
5 tons green manure (*late*)	3,847	80	135.3	52—50

TABLE III.

Green Manure Experiment (b), *Nitrogen Determinations.*

Mgms. of ammonia in 100 gms. of soil at 100° C.

	Before puddling.			After puddling.									
Time of sampling in weeks.	At start.	1	3	½	2	4	6	8	11	15	Nitrogen added as green manure in lb. per acre.	Period of maximum ammonification in weeks.	Maximum percentage ammonified.
Control	1.40	1.26	1.25	1.40	1.60	1.91	1.44	1.44	1.18	1.10	..	2–4	..
Green manure (*early*) ..	1.44	2.39	2.17	1.81	2.48	2.06	1.80	1.91	1.52	1.65	65.5	2–4	24.9
Green manure (*late*) ..	1.47	1.25	1.15	2.32	3.49	3.45	3.27	2.94	1.84	1.77	65.5	2–4	53.4

of the higher plants and his contention is supported by Harrison and Aiyar who conclude that the surface film of algæ is the chief agency in the æration of the roots of rice. It will be seen, therefore, that the role of green manures is a dual one ; they supply for the paddy plant nitrogen in the assimilable form of ammonia and carbon dioxide for the algæ which liberate the oxygen necessary for root growth under the anærobic conditions of paddy fields.

The necessity of obtaining experimental evidence as to the effect of the green manures on yield has been recognized and a preliminary experiment was carried out at Anuradhapura in 1926. There a green manure (*Crotalaria juncea*) grown *in situ* on the paddy fields resulted in a 35 per cent increase of yield in the following crop. The experiment which has already been described (Lord) was not capable of valid statistical examination and moreover the control plots were ploughed later than the treated plots. The experiment, however, pointed out the necessity for obtaining information as to the effect of ploughing in green material at different times before sowing or transplanting the main crop and accordingly an experiment was started at Peradeniya in 1927. This experiment was laid down in collaboration with the Agricultural Chemist in order that the nitrogen changes in the soil could be studied. The treatments consisted of green manures ploughed in 'early' (seven weeks before sowing) and 'late' (one week before sowing), the normal weed growth ploughed in 'early' and 'late' and control plots. The five treatments were replicated four times in randomized blocks and *Crotalaria juncea* was sown on the green manure plots to supply the green material. This growing of the manures *in situ* was not satisfactory owing to the unequal growth on the different plots. Unfortunately heavy rain at harvest time spoiled yield records. The nitrogen changes which took place were extremely interesting and have been published by Joachim and Kandiah who included these results in a comprehensive field and laboratory study of the question. Essentially it was found that after ploughing in both weeds and green manures early there was an appreciable increase in the amount of ammonia present in the soil with but little increase of nitrate nitrogen. After puddling there was a sudden decrease in ammonia content but both plots remained above the level of the controls. The green manure and weed lots ploughed in late reached their maximum ammonification during the time the paddy was in active need of ammonia. Both the late plots contained more ammonia than the early plots and the green manure late more than the weeds late. Table I taken from Joachim and Kandiah shows the actual figures.

The formation of ammonia prior to puddling is probably unusual and due to the plots being water-logged. Normally, as Joachim and Kandiah

have shown, the decomposition of green material prior to puddling results in the formation of nitrates. Nitrates are used by the paddy plants and after puddling (that is, under anærobic conditions) are reduced to nitrites which may be definitely harmful to the plant. Laboratory investigations have shown that it is useless to incorporate the green material in the soil under ærobic conditions unless just prior to flooding the soil.

A similar experiment, slightly modified, was laid down at Peradeniya for the *maha* crop of 1928-29, again with the collaboration of the Agricultural Chemist. In order to ensure that the green manure plots received similar quantities of green material it was decided not to grow the manure *in situ* but to use wild sunflower brought in from outside. The application per acre was 5 tons of the green unwilted material. Green manure ploughed in early and late (respectively five weeks and one week before transplanting) was tested against control plots. There were four replications in randomized blocks and in each 1/80 acre plot an inner area of 1/100 acre was harvested to eliminate border effect.

The results of the experiment will be found in table II.

The test is satisfactory and the standard error of the difference between means is 5 per cent. The increased yields of both the treated plots are significant and green manure *late* has beaten green manure *early*. It will be noticed that this application of a five-ton dressing of green material has had a definite effect on land whose fertility is high as judged by the mean yield of the control plot which was 2,482 lb. per acre.

The nitrogen fluctuations in the plots are interesting and will be found in table III and Fig. 1.* The table and figure have been taken from Joachim and Kandiah with the permission of the authors.

Nitrate nitrogen was not found at any stage during the experiment and it was absent before puddling—the time nitrate can normally be expected almost certainly owing to the plots being somewhat water-logged during that period. Even with soil in this condition the gain in burying the green material late, that is just before puddling, is clearly shown both by the yield figures and by the analyses.

It has been stated in India that the anærobic decomposition of green manures gives rise to toxic products which may effect the germination of the paddy seeds. Pot experiments at Peradeniya have shown that puddling in the green material even one day before sowing has had no effect on germination. To be on the safe side, however, it is recommended that green manures should be incorporated in the soil one or two weeks before sowing or transplanting.

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* Figure omitted in this Journal.—Ed.

It will be noticed that a five-ton dressing of wild sunflower supplies a relatively large amount of nitrogen, roughly as much as is contained in 3 cwt. of sulphate of ammonia. It is quite possible that a one- or two-ton dressing may be the economic or practical limit and it is also exceedingly probable that the addition of some form of phosphate to the green material will be advantageous. In many places it will be impossible to procure sufficient green material to supply a five-ton dressing per acre; so the effect of a one-ton dressing is now being studied at Peradeniya. An experiment has also been devised to test the relative efficacy of green manures and sulphate of ammonia in order to determine, if possible, the actual value of the organic matter in the green material.

The cost of applying green manure has not been mentioned as it varies so greatly according to the ease with which it can be cut and the distance it has to be transported. Many cultivators, too, will be willing to cut green material in their spare time. It is impossible to arrive at any definite cost, although the value may be based on the amount of nitrogen the material contains. The possibility and economy of growing green manure *in situ* will have to be determined by local experience and conditions. In some districts there is insufficient time, in others insufficient water and probably in all insufficient inclination. The practical difficulties are great. Where a paddy crop is not sown cattle graze the paddy fields at will and enclosures after a crop has been harvested are unknown. There is little doubt that *Crotalaria juncea* will do well on drier fields but at Peradeniya on the wetter fields the following have been tried with little success: *Crotalaria juncea*, *C. anagyroides*, *C. usaramœnsis*, *Sesbania cannabina*, *Desmodium gyroides*, *Mucuna sp.*, *Tithonia diversifolia* and *Vigna sinensis*.

Recommendations.

In the present state of our knowledge of paddy cultivation the following practical recommendations may be made:—

1. Green manure can confidently be applied to all normal soils except perhaps those whose fertility is well above the average.

2. One or two tons of green material per acre is a suitable dressing although smaller applications should not be disdained.

3. The green material should be applied as late as possible before sowing or transplanting, say from one to two weeks previously, and after ploughing in the soil should be kept flooded or very moist.

4. With large dressings a cwt. of superphosphate and with small dressings a half to one cwt. of some ammonium phosphate per acre may be recommended.

5. Where weed growth is poor application of inorganic manures should invariably be accompanied by at least a small dressing of green manure.—*The Tropical Agriculturist*, Vol. LXXVIII, No. 1.

Science and Animal Production

Breeding: The Application of Genetics

By Prof. F. A. E. Crew, M.D., D.Sc., Ph.D.

During the last twenty years or so the science of genetics in its applications has revolutionized the methods of plant improvement, but the methods of live-stock breeding have been left untouched by its advances; these remain very much as they were at the beginning of the present century. That this must be so could have been foretold by anyone who knew the techniques of the science and was acquainted with the significant differences between cultivated plant and domesticated animal; but it was not, and to-day the practical benefits derived from plant and animal genetics are contrasted to the detriment of the latter branch of the science. It is forgotten that the usefulness of a science in application is conditioned by circumstances that have nothing to do with the science itself. Farmers do not breed plants; they merely grow the seeds they buy; the actual production of standard and of new and improved varieties on a commercial scale is in the hands of a few highly experienced and expert professionals. When a new variety of proven worth makes its appearance farmers must, for their own sakes, use it, and so an improved variety can sweep its less worthy antecedents out of a country within the space of a few years since seeds are cheap, the progeny of a plant are exceedingly numerous, and generation follows generation very quickly.

But farm animals are not bred by specialist firms, the farmers themselves are the breeders of live-stock, and if improvement through breeding is to be attained, it is to the farmers themselves that we must look for methods of breeding that will yield advance. The task of these amateurs in breeding is far from simple, the individual animal has a high monetary value, a prolonged period of immaturity, a complex sexual and reproductive life, a low reproductive rate and the standards of excellence in the case of animals are commonly and necessarily so vague and unsatisfactory that even though the breeder knew how to obtain improvement through breeding, he would still be unable to describe and define improvement.

We may assume that because it was obvious that no private individual could hope to devise and employ methods of animal improvement equivalent to those which have led to continuous advance in the field of plant-breeding, that State-created and aided institutions of research in animal genetics were organized. Certainly, there has never been any reason to doubt that genetics in its applications could serve animal-breeding as thoroughly as it has served plant breeding, but it was recognized that just as genetical analysis and synthesis in the case of the plant required scores of generations and hundreds of thousands of individuals, so, before an equally useful body of knowledge relating to the

domesticated animals could be amassed, a more or less equal amount of genetical work with them must have been pursued. Such work must demand more than a single lifetime, and so research institutions, which outlive many generations of men, have been created where specialists have their being and in which experimentation can be continued to its conclusion.

But from these research institutions nothing has yet come that has affected live-stock breeding practices for the reason that, in the first place, it is too early to expect results, and in the second, there is no institution in this country equipped for the undertaking of genetical research with any animal of economic importance save the fowl and the rabbit. Though there are men on the staff of these institutions who are qualified to undertake experimentation with the larger domesticated animals, they have to content themselves with herd-book analysis and with the attempted interpretation of the observations of private breeders. All that has been possible has been to examine the different systems of breeding in the light of genetical fact and theory in an attempt to discover which of them in given circumstances merit scientific endorsement.

If genetics has a role to play in live-stock breeding it is that of defining and of securing a biological type which will harmonise with a predetermined habitat and destiny. The ideal type is that which, in virtue of its hereditary constitution, can flourish under the peculiar conditions of the region in which it is to have its being and which will provide easily and economically the commodities for which it is bred. The ideal can only be described when the habitat and destiny have been defined, and it must refer not merely to one function of the animal but to the animal as a whole—the ideal milking cow must not only produce milk of a certain quality and quantity, but she must also live, thrive and reproduce in a particular environment. Standards of excellence are sometimes not consistent, and often the terms in which they are stated do not come close enough to the realities of structure and of function ; and when this is so, genetical experimentation cannot do much to help, for this is concerned not with the nature of an inherited character but with the mode of its transmission from generation to generation. Until the character has been described, it is difficult to trace its inheritance. In this connection it is to be noted that during recent years improvement has occurred mainly in the case of those domestic animals the quality of the produce of which can be measured—the dairy cow, the laying hen and the wool-bearing sheep. The meat breeds have not been improved to the same extent for the reason that meat production is a quality that is not so amenable to measurement.

The scientific measurement of excellence is an urgent necessity and a prerequisite to all intelligent attempts to secure it : excellence must be

defined in relation to the whole life of the animal, and in regard to the entire scheme of economics under which the stock is being produced. If and when excellence has been defined in terms of realities, next comes the problem of demonstrating the mode of inheritance of the desired characteristics and of determining the relative roles of nature and of nurture in the production and maintenance of these. But *ad hoc* experimentation will always be expensive and very slow, and it is improbable that we shall possess exact data extracted from specially planned experiments and relating to the mode of inheritance of characters of economic importance for a long time yet. In the meantime, we must seek information as to which characters are inherited, and how far they are affected in their expression by environmental influences. Research in the fields of the genetics of live-stock must continue to be of the nature of pre-Mendelian biometry until critical experimentation becomes possible.

The first stage in any programme of live-stock improvement in a country is the provision of pedigree sires. It is true that an individual with a large number of "good" ancestors is more likely to produce "good" offspring than is an animal equally "good-looking" but with a large number of ancestors of indifferent quality. Used in a rational fashion, the pedigree system provides most useful information, and it is in accord with genetical teaching. But genetics also teaches that the length of the pedigree is not a measure of its value, that there is no advantage in considering a pedigree beyond the fourth generation back. Pedigree, genetically defined, means homozygosity in respect of characterization, that is to say, the pedigree individual in virtue of its hereditary constitution, can stamp uniformity and quality equal to its own upon its offspring.

But as a measure of homozygosity the progeny test is more valuable than is pedigree. This is the teaching of genetics. The test itself of course is not new. Bakewell of Dishley used it to the fullest extent, but save for one or two exceptions most breeders seem to have failed to appreciate its value. The test, to be of service, demands that the husbandry to which the off-spring are exposed shall not be less good than that encountered by the sire, for the genetic relation between similarities and dissimilarities exhibited by members of successive generations cannot be determined unless the environment is standardized. If there is forced feeding of a high priced sire but no equivalent feeding is forced on his sons, then any comparison of the generations is clouded.

As a means of securing homozygosity, inbreeding accompanied by rigorous selection has been mainly employed by the breeder, and it is the method which the science of genetics would itself suggest in the case of a stock which was known to be free from hidden recessive characters of an undesirable kind.

Thus, the methods of producing pedigree sires are genetical methods, and demand for their intelligent application a knowledge of the science.

The next step in live-stock improvement is the use of pedigree sires on commercial stock. The genetical endorsement of this policy lies in the fact that the pedigree sire is homozygous and therefore prepotent in respect of the admirable qualities for which he has been bred, and thus impresses these upon the heterozygous commercial stock, reinforcing good with good and covering recessive bad with dominant good. But pedigree stock does not constitute 5 per cent of present-day farm live-stock in this country; and furthermore no adequate use is being made of what there is; we breed them for export to our competitors, and buy back their progeny as "stores" or as carcasses. It is estimated that in Great Britain and Ireland each year a million unwanted calves are born. They are unwanted because they are practically valueless, and they are valueless mainly because they are out of dairy cows by scrub bulls. They are born because at the present time before there can be milk there must be a calf. Common sense endorsed by genetical fact suggests that it would be infinitely better to use a pedigree bull of a beef breed on dairy cows, and thus to get a calf that possessed a value of its own. It is worth noting that there is no scrub bull in Ireland and Irish "stores" find a ready market in Great Britain. There is no sounder policy, according to genetical teaching, than that which advocates the eradication of the scrub bull of unknown and definitely mixed hereditary constitution.

Finally, genetics has its contribution to make towards the solution of the problem of the elimination of the undesirable. If any undesirable character is inherited, and if it is incurable by medical or surgical means, or if its cure is tedious and expensive, then its eradication from a stock can only be effected by the application of genetical procedure. Most defects and derangements of live-stock are necessarily inherited as recessive characters, and are commonly based on more than one hereditary factor. This being so, it becomes necessary to know that the males that are to be used as sires do not exhibit such a character and to demonstrate that they do not carry in their hereditary constitutions the recessive factors corresponding to these. All males exhibiting undesirable characters known to be inherited should, according to the teachings of genetics, be castrated, and ideally, if a study of pedigree indicates that a male of excellent personal quality may be carrying the factors for some undesirable character, he should be mated to a dozen related females, themselves normal but known to have produced offspring exhibiting the undesirable character in question, and then, unless none of the offspring of these matings exhibit the undesirable character he should be castrated.

Unless other and simpler methods, for example some form of laboratory test, are devised, it will remain impossible for the great majority

of breeders to use this test for the " carrier " sire. All that can be suggested is that if and when the incidence of a seriously detrimental character in a breed becomes high, the State itself, if the breed is to be purged of its disqualifications, may have to undertake the testing of the sires.

LIVE-STOCK IMPROVEMENT IN THE COLONIES (TROPICAL).

It is inevitable that anyone from a country which is populated with the greatly improved breeds of European creation should regard the indigenous stocks of a tropical or sub-tropical region as inferior both in structure and function, and that the man whose task it is to improve such "native" stocks should at once attempt to do so by importing sires of European breeds. It is too readily forgotten that the animal in its form and function is fashioned by a variety of agencies, *e.g.*, (1) the type of husbandry which itself is conditional among other things by peculiarities of the social structure, *e.g.*, by regional theologies ; (2) the kind and constitution of the pasturage and other available feeding materials ; (3) the disease-producing factors of the environment ; and (4) the climatic conditions generally. Furthermore, the appointed destiny of domesticated animals is not the same in all communities. If in the New Hebrides a pig, to possess the highest value for sacrificial purposes (and this is one of the principal reasons why pigs are bred there) must be an intersexual, there is not much point in introducing Danish pigs, unless the Danish point of view concerning the pig and the Danish systems of husbandry and of marketing are also introduced.

The only sure method of improving a stock and by that we too often mean of making it similar to those of our own country—is to improve the stock-breeder, the systems of husbandry and the environment ; or in other words, to make the country and its people like our own. And, it may be asked, if this from the point of view of a subtropical colony is really improvement, habitat and destiny create harmonious biological types. Ayrshires will continue to remain Ayrshires only so long as they live in an Ayrshire, which is not a country of Scotland but is a peculiar combination of human stock, social organization, husbandry and climate. Transplant the Ayrshire and it will become more or less different, better or worse. Change the environment and the local stock can become Ayrshires. The attainment of absolute homozygosity in the case of the larger domestic animals is impossible, and so when different selective agencies operate upon these they will yield different end-results.

Importations, therefore, should ideally be made from stocks of higher quality, measured by the prevailing local yard-sticks, which have thriven in conditions as similar as possible to those of the country into which they are to come. Of course it may well be that in certain circumstances a newly-evolved type may prove to be superior to an already existing stock. Experiment alone can determine this. In the West Indies it seems likely that Zebu × European stocks thrives as well and performs

even better than the native stock of cattle. But it still has to be shown that continued selection in a given direction among the native stock would not lead to very considerable improvement. In a hundred years or so such selection, in the hands of the breeders of this country, has changed the breeds out of all recognition in respect of conformation and performance. The fact that native stocks are commonly very heterogeneous, and therefore exceedingly malleable, and have not been exposed to the methods of improvement which fashioned the modern European breeds, permits us to assume that what has been accomplished here could be achieved elsewhere. Doubtless, the aims of selection would be different; they would necessarily be required to relate to the peculiar conditions of the particular regions concerned. Such selection must be amazingly effective in a relatively short time if it is used for the exaggeration in expression of inherited characters unaffected by the phenomenon of dominance. In instances in which dominance is not involved and in which the stock is very heterozygous, even though the genetic basis of a desirable character is complex, many factors being involved, selection will quickly work wonders. It has yet to be shown that grading-up of native stock by the use of imported European sires is in its effects upon a live-stock population more rapid than such selection. Furthermore, in such importation, the hereditary constitutions of sire and dam are so different that variation due to segregation among the insufficient number of individuals of subsequent generations must commonly be too great for any hopeful attempt at analysis and interpretation being made. It is simple to raise an improved first filial generation; the problem is that of deciding what to do with the second and the third, particularly if selection in respect of some later expressed functional quality has to be made in advance.

The Future.

In view of the facts that most of the inherited characters of live-stock which are of economic importance have no counterparts in the ordinary animal material of the geneticist, and that they seem to be multi-factor in nature and profoundly influenced in their expression by conditions incidental to development, it is not likely that much of real and immediate practical value will emerge within a reasonable time from such genetical investigation as is now proceeding. It is not improbable that, long before the repercussions of genetic investigation are felt, advances in the fields of endocrinology will have furnished us with tools with which we shall be able to control many of the physiological processes which determine the quantity and quality of an animal commodity. Already we know a great deal concerning the hormones that regulate the functions of the body, for example, the growth hormone, the œstrus-inducing hormone, the pregnancy-promoting hormone, and there can be no doubt that

shortly these will be used deliberately for the purpose of guiding development in special directions. To hasten the onset of sexual maturity, to intensify sexual activity, to prolong the sexual life of the individual, to induce œstrus at any time, or to exhibit it at will, to induce changes in the reproductive organs that will make pregnancy far more certain, to induce pregnancy changes in the organism in the absence of fertilization, to control the intensity of the material instinct, to speed up growth, to regulate size within limits—all these and more are no longer vain dreams but reasonable expectations. The task of genetics in the future may be the synthetic production of animals which, in virtue of their hereditary constitution, will be able to respond in different directions to the specific stimuli of different hormones and when these have been produced in pure form and analysed, of different synthetic preparations of the chemist. Then there may be very simple solutions of the various problems that presently beset the live-stock breeder. At the moment, there is no appreciable reason why continuous lactation should not be induced by the removal of the ovaries of commercial dairy cattle. This practice would remove the necessity for a bull in those very herds in which the scrub bull is used and at the same time remove all œstrous disturbances, all the difficulties associated with irregular breeding and with contagious abortion. It would give a greater control of the sires used without any economic interference with the production of milk. But in the future if and when pseudo-pregnancy in the dairy cow can be induced by such means, as it can even now be imposed upon smaller mammals, milk production will be initiated and maintained without any bull and without any calf, and the problem of the scrub bull will have evaporated.

But it is more fitting to end on a subdued note. The problem of the control of the sex-determining mechanism is still unsolved. Yet this is one of the major problems of the dairy industry. We know how the sex of the calf is determined, and that if we could but separate the two forms of sperm elaborated by the male, we should have the control of the sex ratio in our possession. It is unlikely that this problem will be solved until a group comprising physicists, chemists, biochemists, physiologists and geneticists has been collected and inspired to undertake the task of solving it. I expect to be told that the problem has already been solved by the application of some variant of the Rumley-Dawson hypothesis, or of the Hofacker-Sadler law, but I beg leave to doubt it.

Genetics will not influence live-stock breeding practices until it is offered to the students of agriculture and of veterinary science as part of their curricula. Until this is so, the geneticist and the live-stock breeder can have no common language, for genetical terms are not to be found in the advertisement columns of agricultural weeklies.—*Agriculture and Live-Stock in India*, Vol. II, Part IV.